Next 1 Page(s) In Document Exempt

TOP SECRET

PROJECT ICE

SELECTED PHOTOGRAPHIC EXAMPLES

FOR

ICE RECONNAISSANCE

Reviewed by NGA.

TOP SECRET

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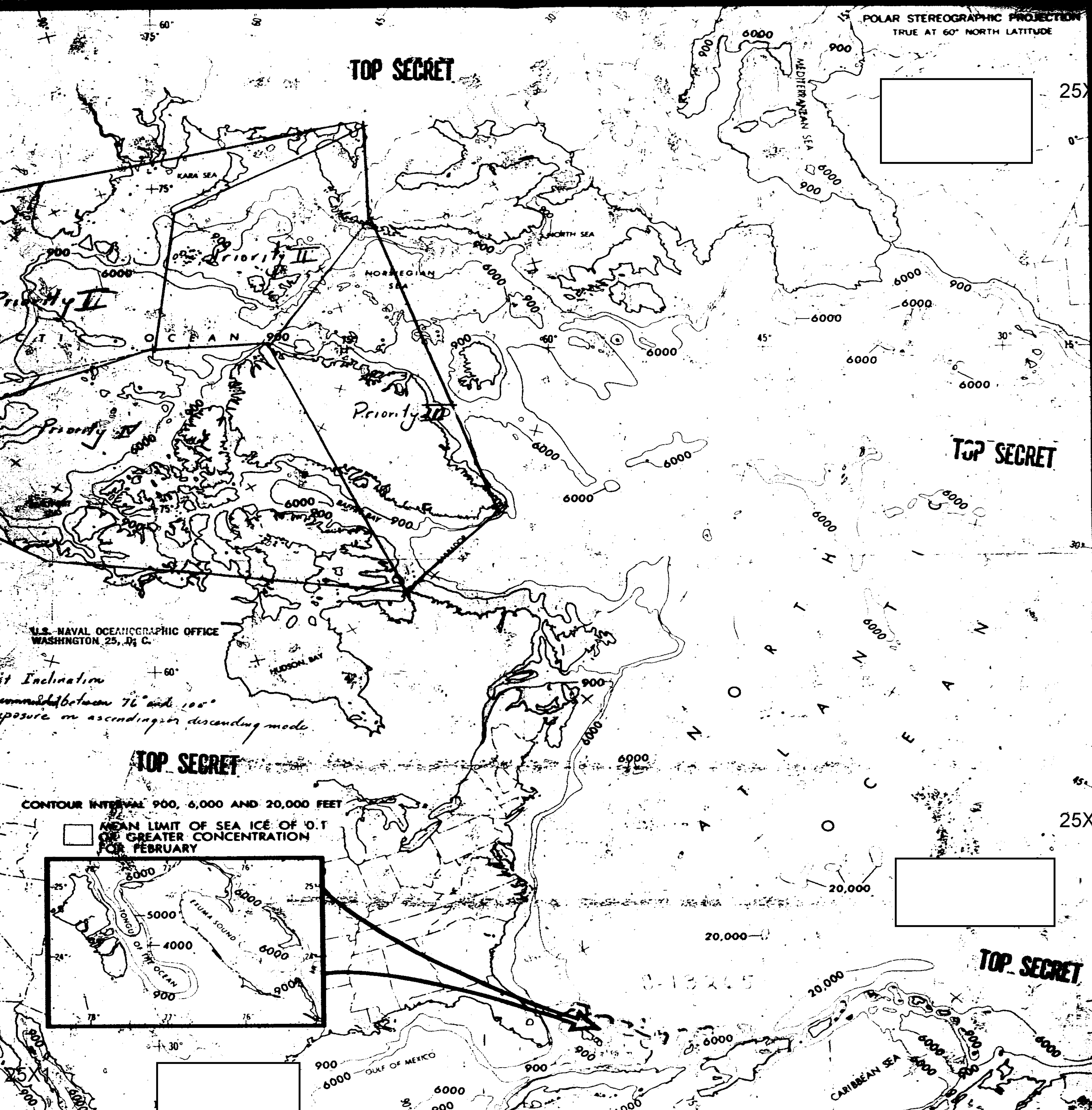
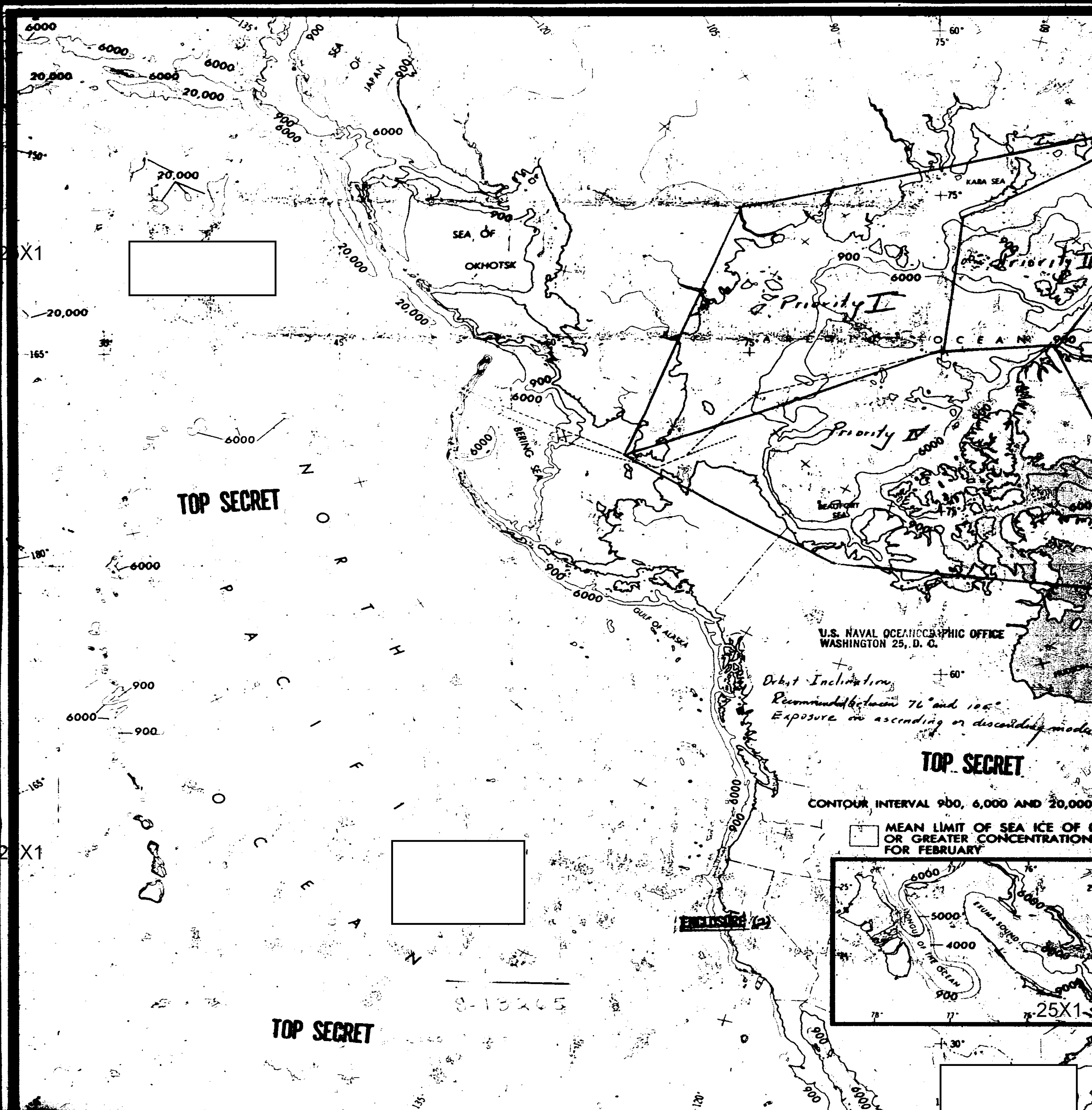


POLAR STEREOGRAPHIC PROJECTION
TRUE AT 60° NORTH LATITUDE
TOP SECRET
25X1
KARA SEA
NORWEGIAN SEA
NORTH SEA
MEDITERRANEAN SEA
Priority II
Priority II
Priority III
Priority IV
OCEAN
BAFFIN BAY
HUDSON BAY
NORTH ATLANTIC OCEAN
TOP SECRET
U.S. NAVAL OCEANOGRAPHIC OFFICE
WASHINGTON 25, D. C.
t Inclination
between 76° and 100°
posure on ascending or descending mode
TOP SECRET
CONTOUR INTERVAL 900, 6,000 AND 20,000 FEET
MEAN LIMIT OF SEA ICE OF 0.1
OR GREATER CONCENTRATION
FOR FEBRUARY
25X1
TONGUE OF THE OCEAN
EXUMA SOUND
GULF OF MEXICO
CARIBBEAN SEA
TOP SECRET
25X1

25X1 [redacted]



25X1 [redacted]

[redacted]

25X1 [redacted]

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May 1964

Project - Ice Coverage Evaluation

U. S. Naval Oceanographic Office
Naval Reconnaissance and Technical Support Center

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[redacted]PROVEMENT OF AERIAL ICE RECONNAISSANCE TECHNIQUES

INTRODUCTION

For the past several years all Polar Military operations have been actively supported by the ice reconnaissance and forecasting program conducted by the U. S. Naval Oceanographic Office. In these operations the services provided have been demonstrated to be of significant value; further, it is probable, in the event of emergency, that the requirement for an adequate ice prediction service will become more significant.

Although considerable effort, within the limited funds available, has gone into the development of objective ice prediction techniques, it is nevertheless true that, no matter how advanced the prediction technique, the accuracy of ice forecasts depends to a very great extent on the number, simultaneity, and reliability of ice observations. Although reports are received from ships, shore stations, and drift stations, the Navy's ice operational program has been based mainly on aerial ice reconnaissance. Depending on requirements, this reconnaissance is carried out according to a regular program over the marginal Arctic packs, the Arctic Basin, and Antarctica.

Although aerial reconnaissance has been up to now the most efficient means available and the ice prediction program could not have been developed without it, the technique has various serious deficiencies which will inhibit further development of the program. These may be summarized as follows:

(1) Aircraft flights obtain only a small (30 mile wide sweep) of data on ice conditions on each flight. In some areas, such as the Polar Basin, this sample is not very significant compared to the total ice area, and inhibits understanding of the behavior of the ice pack. Adequate coverage by aircraft would be exceedingly expensive and in some areas impossible.

(2) The effectiveness of aerial reconnaissance is further reduced by the typically bad weather over most Arctic areas during a considerable portion of the year. These periods are most prevalent during Spring and Summer, which are those of greatest operational activity. It is not feasible to conduct flights with sufficient frequency to provide effective coverage of the area of interest or to observe short-term variations in the ice pack.

(3) The scarcity of Arctic bases close to ice areas creates a considerable amount of "dead time" between available air bases and the ice. This difficulty is enhanced by the limited range of most aircraft when operating in polar areas.

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(4) Although research experiments are carried out using aerial photographs, the extremely small sample available makes photographic techniques infeasible as an operational procedure. Visual observations are therefore the predominant method of collecting ice information. This subjective method of report and extremely complex medium results in considerable observer error and variation in reports from observer to observer. This greatly inhibits the development of objective forecasting techniques requiring reliable digital inputs.

(5) As yet no operational means are available for obtaining ice data during the Arctic night.

Based on the efforts expended by both aircraft units and the Oceanographic Office, it is estimated that the aerial reconnaissance program in the Arctic and Antarctic costs the Navy nearly $1,000,000 yearly. In view of the importance of the program, and the fact that further development is being adversely affected by data of doubtful quantity and in some cases no data at all, it appears mandatory that the Oceanographic Office intensively study means by which the quality and quantity of ice observations available may be significantly upgraded. In considering this problem, there are two major areas that have been considered. The first is to find a platform superior to the aircraft; the major possibility here is the satellite. The second is to develop better sensing devices for observing ice features; the two most promising methods here are infrared, which could provide information during the Arctic night, and radar, which would provide both an all-weather and all-season capability. It is pointed out, however, that, valuable as these latter two techniques might prove, should they be used from aircraft many of the deficiencies of the aircraft as an Arctic reconnaissance vehicle would remain.

SATELLITE PHOTOGRAPHY

The Oceanographic Office has engaged in several activities aimed at assessing the applicability of satellite photography to ice reconnaissance. These may be summarized as follows:

(1) Examination of TIROS I and II photographs, although not supported by independent observations by other methods, indicated considerable promise. Page 1, a mosaic constructed

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from TIROS II material, indicates that, with proper satellite characteristics, it should be possible to identify ice features accurately. This mosaic was constructed with photographs using a narrow angle (12.7°) camera system on TIROS II.

(2) Based on those results, the TIREC experiment was designed and carried out in the Newfoundland area during the period immediately after the launch of TIROS IV. An intensive program of aerial photography was conducted by the American Navy and Canadian Air Force, with the intention of comparing the satellite and aerial photography. Unfortunately, the narrow angle camera system was eliminated from the TIROS IV satellite, and is not planned to be included in either subsequent TIROS launches or in the first three NIMBUS vehicles. Pages 2 and 3 show two examples of comparisons between TIROS photographs and aerial mosaics. It can be seen that the results are rather disappointing as far as ice detail is concerned. The only parameter that can be positively identified is the ice boundary; the resolution is too coarse to yield information on important ice features. This study has been completed and a report will be prepared in the near future.

INFRARED PHOTOGRAPHY

The Oceanographic Office has been interested in using infrared techniques to measure sea surface temperature, and has developed equipment for doing this. Recently, during Arctic operations in collaboration with the Cold Regions Research and Engineering Laboratory of the U. S. Army Engineers, opportunity was afforded to obtain simultaneous aerial photographs and infrared imagery over ice areas. One of these comparisons is shown on page 4. Such a device looks promising as a means of sensing ice features from aircraft as well as from satellites, and thus would extend our capability to include the winter months.

RADARSCOPE PHOTOGRAPHY

Previous experience in attempting to interpret radarscope photographs for ice information have been extremely disappointing. These studies have been mainly carried out with the standard

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radar aboard ice reconnaissance aircraft. Recently, however, photographs have been obtained by the APQ-56 side-scanning radar, during a flight of USAF reconnaissance aircraft over the Arctic Basin. An example of these photographs is shown on page 5. These photographs, taken from 65,000 feet through many thousands feet of solid cloud, are quite remarkable in their detail; such a device would be a valuable addition to the equipment aboard the WV-2 aircraft assigned to the BIRDS EYE project over the Arctic Basin.

OPTICAL IMAGERY FROM SATELLITES

From the foregoing it is clear that, while the aircraft is valuable for tactical support and providing the gross features of the synoptic ice situation, the satellite offers more promise as a vehicle for obtaining detailed ice information on the large scale necessary to provide adequate ice prediction support anywhere in the polar regions. Further, although telemetered imagery such as the TIROS and NIMBUS material do not as yet provide sufficient resolution, optical photography, infrared, and certain types of radar all show promise as ice reconnaissance sensors. Although the latter two can provide useful data from aircraft, the technology of applying these techniques from satellites is still in an early stage of development. It appears logical, therefore, to investigate the feasibility of using optical photography from satellites as the most promising synoptic ice reconnaissance technique at this time.

This problem has been investigated in a preliminary fashion by the Naval Oceanographic Office, the Naval Reconnaissance and Technical Support Center, and the Astronautics Office of the Bureau of Naval Weapons under a contract with Autometric, Inc. The material used was obtained by the geodetic mapping camera [redacted] materials.

Examples of this material are shown in stereo form on pages 6, 7, and 8. Examination shows that it is possible to clearly discern the major ice and open water features with the exception of features smaller than 250 feet : such as ridges and cracks. From this material, Autometric was able to compile rather complete statistics of the ice canopy over a significant portion of the Arctic, detailed in their first formal report on Project ICE. Another study along the same line, using later material of the same type, is now underway.

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Although the [redacted] material is extremely useful for ice study because of the availability of considerable Arctic material, it would be of value to study material which would yield information on the finer ice structure. A preliminary investigation of other possible imagery has been made by NPIC, with the result that, while little Arctic Basin data is presently available other than [redacted] possibilities exist to obtain valuable detailed ice information from other sources.

Page 9 shows an example of photography obtained by the present frame camera of the KH-4 System. It will be noted that the resolution and detail is at least as good as the [redacted] material, as well as covering a much greater area per frame. The scale of the detail that can be studied is illustrated on pages 10 and 11, which are examples of the frame imagery enlarged 4 times. This photography is of particular interest in that requirements do not at present fully utilize the capacity of the camera system; it should therefore be possible to obtain a significant amount of Arctic imagery with this camera.

Pages 12 through 15 illustrate the capability of the KH-4 panoramic system to obtain ice data in the detail required for research into ice behavior. With a scale of about 450,000, it can be seen that such details as small floes, cracks, and in some cases ridges can be clearly identified, as well as clear indications as to the age and type of ice. Pages 12 and 14 represent two separate cases in Arctic waters, while pages 13 and 15 are vertical transformations of the pictures.

Even more detailed data can be obtained by use of the KH-6 and KH-7 imagery. Page 16 contains an example of the present KH-7 photography, with a scale of 100,000. The detail that can be seen rivals, if not surpasses, that available from aerial ice photography used previously, at the same time providing a synoptic picture over an area several orders of magnitude large than conventional aerial photography. Page

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17 is a similar example of the now discontinued KH-6 material, with a scale of 80,000. While it is unrealistic to expect large quantities of Arctic data from either the KH-4 panoramic or the KH-7 systems, occasional exposures to provide additional data in operationally important areas or to study closely short-period time changes in the ice structure would be extremely valuable.

RECOMMENDATIONS

Based on the discussion above, it is clear that the satellite, when combined with optical photography, overcomes most of the objections to the use of aircraft for ice reconnaissance. While other requirements obviously take precedence over the obtaining of ice information from present systems, the capability should be fully exploited whenever feasible. To this end the following recommendations are offered:

1. Operate the framing camera of the KH-4 system on a continuous basis to obtain maximum Arctic Basin coverage.

2. Where requirements permit, obtain occasional exposures of ice-covered waters with the KH-4 panoramic fore and aft camera, the exact time and place to depend on the environmental, seasonal, and operational situation at that time.

3. Establish a small group to consist of ice experts from NAVOCEANO and photographic experts from NRTSC to fully exploit the material in development of techniques to support naval operations.

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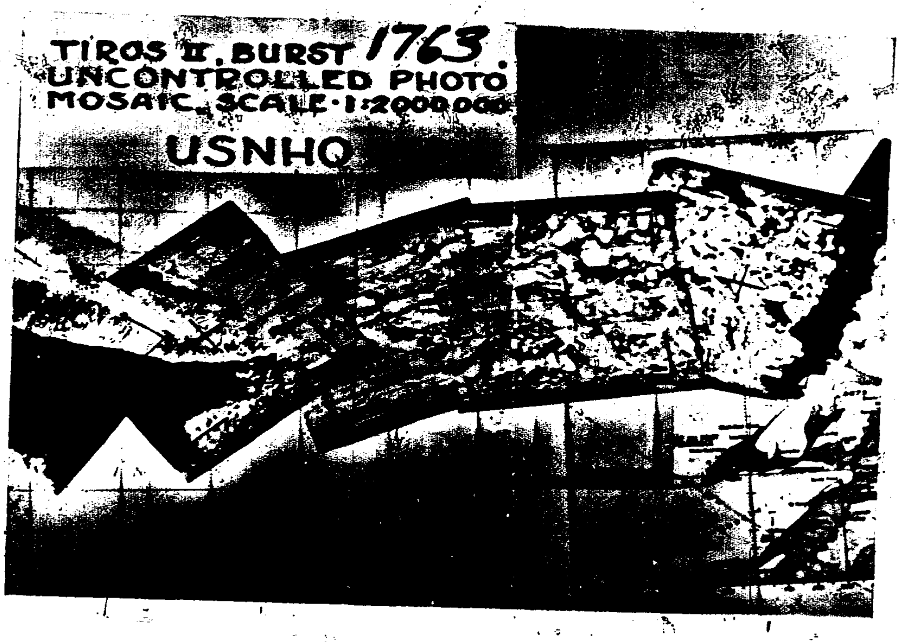
TIROS II, BURST 1763.
UNCONTROLLED PHOTO
MOSAIC SCALE 1:2000000
USNHO

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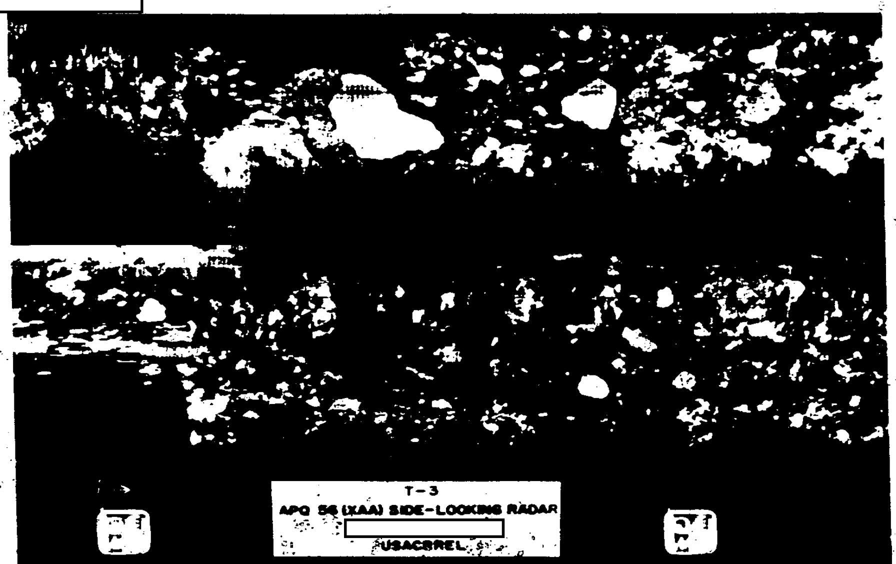
SIDE-LOOKING RADAR



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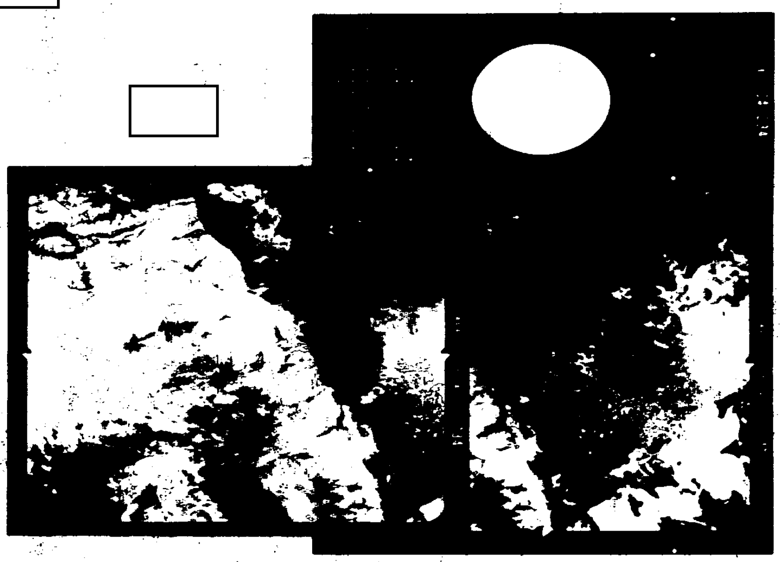

SAKHALIN ISLAND

LAT 55°N LONG 142°E

APPROX SCALE 1:4,000,000

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TOP SECRET [redacted]

[redacted]

[redacted]

WHITE SEA

LAT 67°N LONG 45°E

APPROX SCALE 1:4,000,000

TOP SECRET [redacted]

[redacted]

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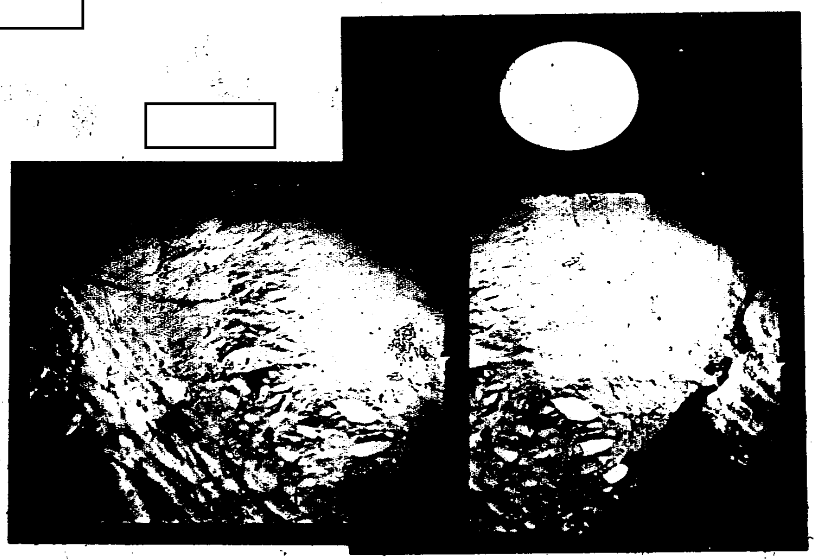
TOP SECRET [redacted]

[redacted]



NEW SIBERIAN ISLANDS

LAT 75°N LONG 150°E

APPROX SCALE 1:4,000,000

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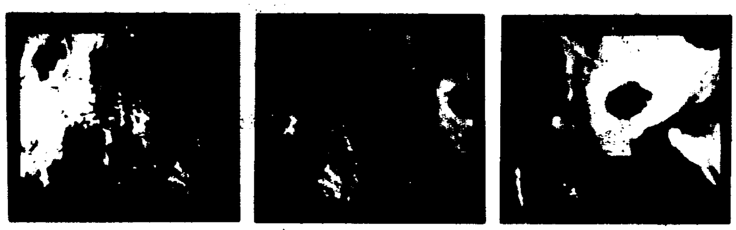
KH-4 FRAME CAMERA



WHITE SEA

LAT 67°N LONG 45°E

APPROX SCALE 1:7,000,000

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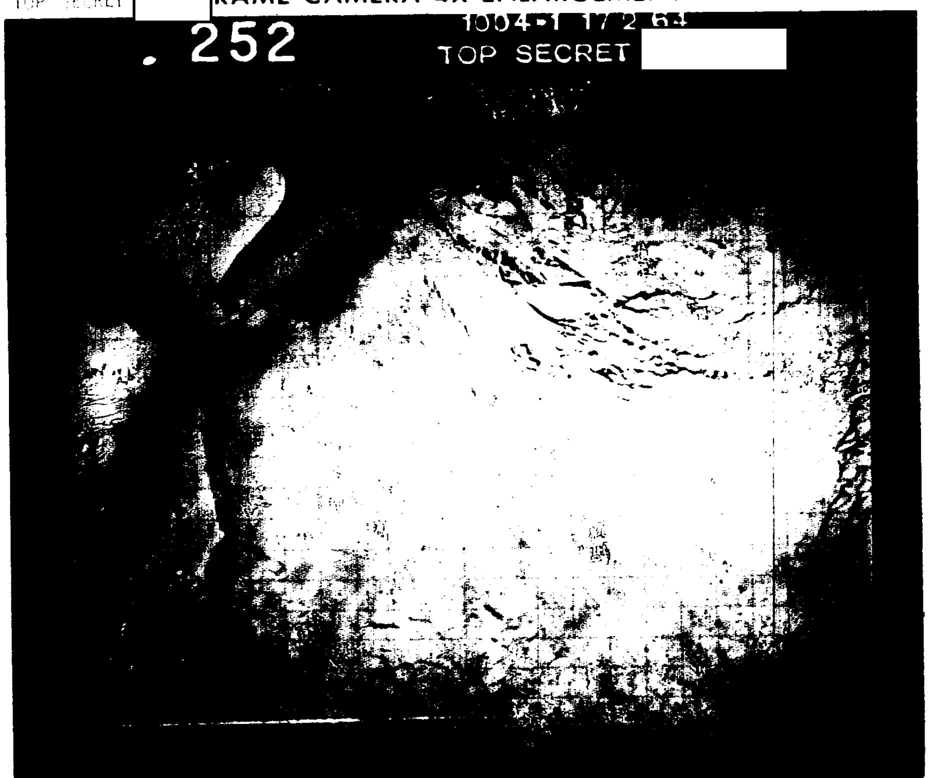
TOP SECRET [redacted] RAME CAMERA 4X ENLARGEMENT



SAKHALIN ISLAND

LAT 54°N LONG 147°E

APPROX SCALE 1:1,750,000

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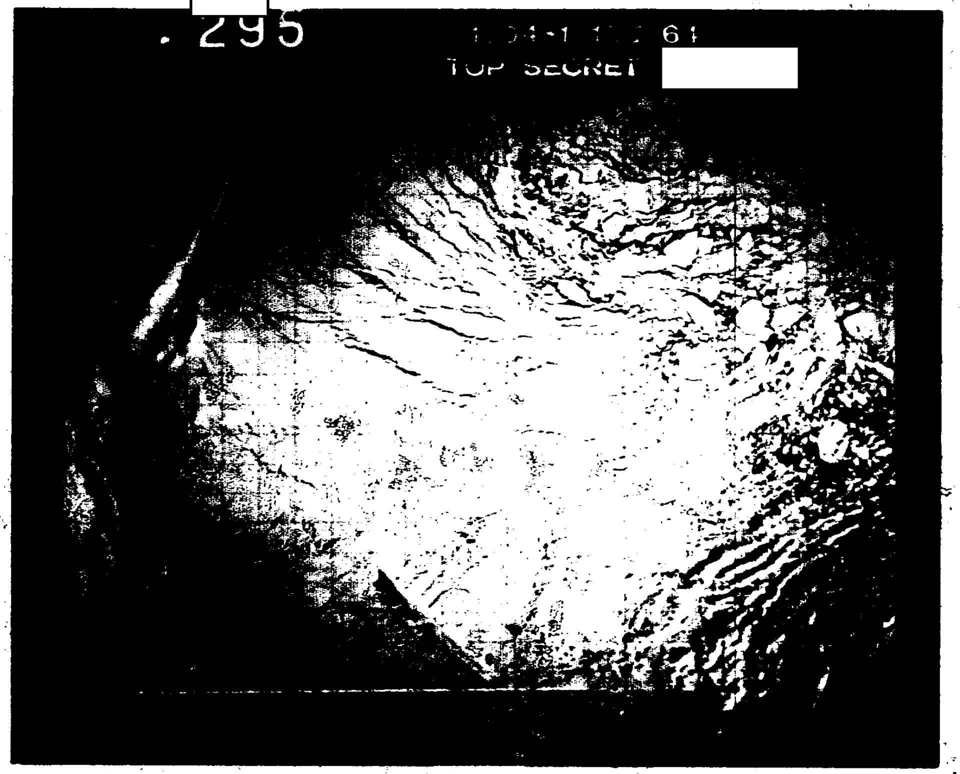
TOP SECRET [redacted] FRAME CAMERA 4X ENLARGEMENT



EAST SIBERIAN SEA

LAT 70°N LONG 170°E

APPROX SCALE 1:1,750,000

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